THE FREE ATMOSPHERE.[1]

THE publication referred to below adds yet another to the series of memoirs issued by the Meteorological Office in the past few years. It furnishes an example, of comparatively rare occurrence in original scientific investigation, of the successful cooperation of private and official enterprise.

The introduction by Dr. Shaw contains a short historical account of the progress made in the investigation of the upper air and a summary of the more important results obtained. It includes a welcome bibliography of the chief English publications on the subject.

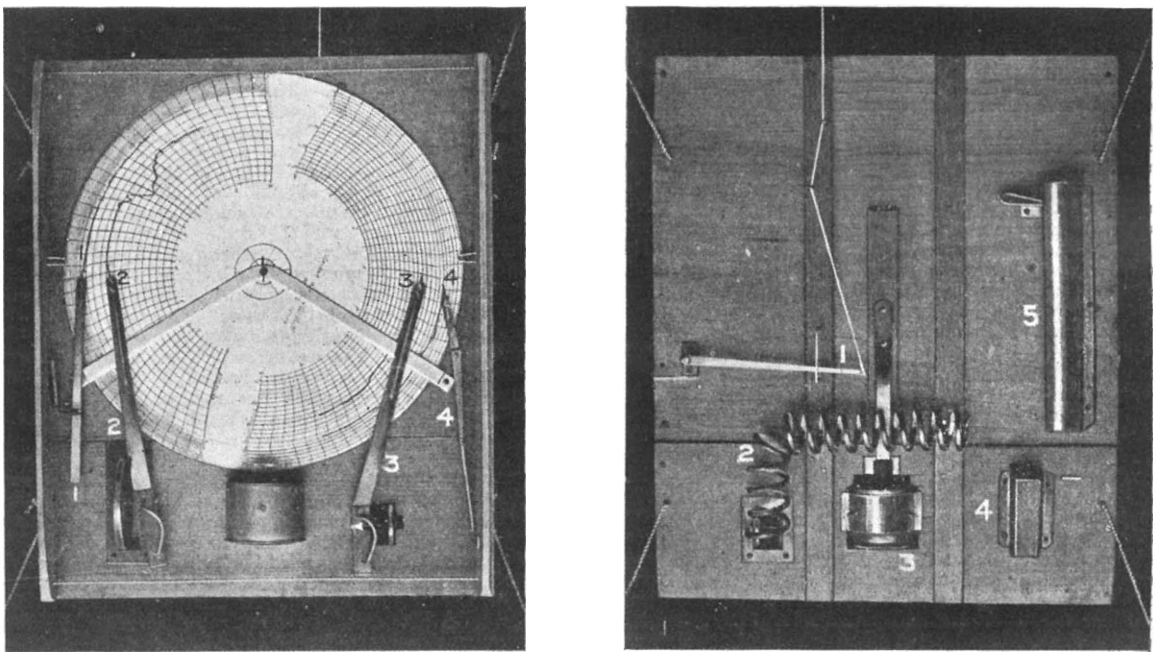
The work in this country was begun so long ago as 1749 by Wilson and Melville, of Glasgow, and the balloon ascents of Jeffries, and, later, of Welsh and Glaisher, maintained our position in the forefront of upper-air research. After a period of comparative inaction, the investigation was renewed at the instigation of Mr. Dines at the beginning of the present century. Dines began his work on the west coast of Scotland in 1902–4, and continued it, first at Oxshott, 15 miles south-west of London, and afterwards at Pyrton Hill, 40 miles west by north of London.

The report deals with kites, pilot balloons, and registering balloons, and contains a summary and brief discussion of the results obtained.

Three kinds of kites, all of the box pattern, are used at Pyrton Hill. No. 1 is 9 feet high, and has sails 3 feet wide and 18 feet long. It is used in light winds. No. 2, for standard use, is very similar, but the sails taper from 3 feet at the front and back sticks to 2 feet 4 inches at the sides. No. 3 is only 7 feet high, and the sail edges form arcs of circles, the width of the sails being 2 feet 6 inches at the sticks and 1 foot 6 inches midway between them. This kite is used if the wind aloft is likely to exceed 40 miles per hour. Steel piano wire, 1/32 inch in diameter, having a breaking strain of 250 lb., is used with all the kites.

If, when a kite is flying, it appears probable that putting on more kites, or letting out more wire, will increase the strain to more than 100 lb., the attempt is not made owing to the risk of breaking the wire, especially as records from greater heights can be obtained with registering balloons. It ought, however, to be borne in mind that the results for temperature and humidity obtained by balloons are less trustworthy than those obtained by kites, and this is of especial importance in connection with the daily variations. A kite can be kept for some time at a nearly constant level, and the kite and instruments remain exceptionally well ventilated without artificial means.

Dines's use of embroidery cambric at 9*d.* per yard, and black dress lining at 5*d.* per yard, for his sails recalls Stokes's marked preference of candles for his optical experiments. The art of using the simplest things to the best advantage runs some danger of being lost in the laboratories of ready-made apparatus and "arranged" experiments. It is refreshing to find instances of it in an official publication.



A FIG. 1. B

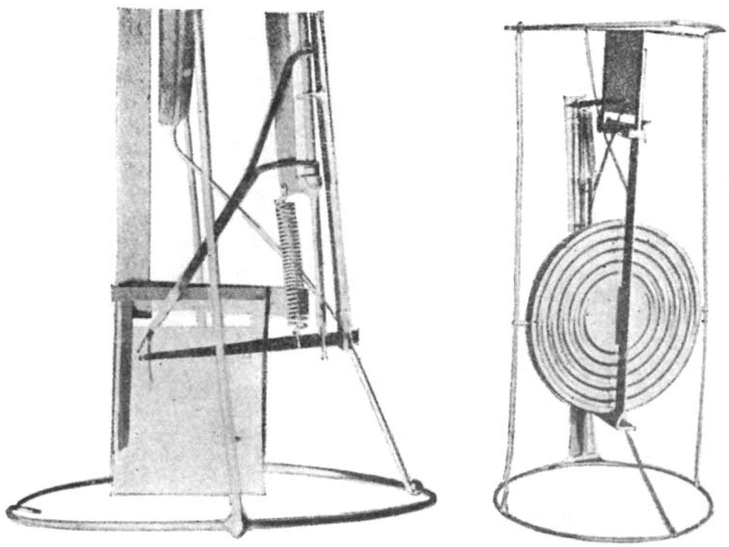
A good deal of trouble is taken to make clear, by diagrams and description, the method of letting-out and winding-in the kite wire. Mr. Dines having discovered, by long practical experience, the places where difficulties arise has taken the trouble to invent the necessary safeguards and to give to others the benefit of his labours.

The meteorograph used with kites is shown in Fig. 1, A, B.; Fig. 1, B, shows the exposed under-surface of the apparatus. The separate parts are (1) the lever and thread of the anemometer; (2) the thermometer, a spiral metal tube containing spirit; (3) the clock; (4) the cover of the aneroid barometer; (5) a metal cover protecting the hair of the hygrometer. In Fig. 1, A, the recording pens are (1) humidity, (2) atmospheric pressure, (3) temperature, (4) wind velocity. The surface shown in Fig. 1, A, is covered by waterproof cloth

[1] M.O. 202. "The Free Atmosphere in the Region of the British Isles." Contributions to the Investigation of the Upper Air, comprising a Report by W. H. Dines, F.R.S., on Apparatus and Methods in use at Pyrton Hill, with an introduction and a note on the Perturbations of the Stratophere by Dr. W. N. Shaw, F.R.S., Director of the Meteorological Office. Pp. iv+56. (London: H.M. Stationery Office, 1909.) Price 2*s.* 6*d.*

when in use. The instrument is tied in the middle of the kite, partly for convenience, partly, presumably, to shelter it from direct sunshine.

The record is made on the cardboard disc shown in



A FIG. 2. B

Fig. 1, A. The difficulty of procuring cardboard which is not warped by varying humidity, and the occasional thickening of the trace through the running of the ink, suggest that it would be an improvement to use a smoked metal sheet.

The anemometer deserves special mention because it is simple and unique. It consists of a light celluloid ball of 3 inches diameter suspended by about 40 feet of fine cotton, and the velocity of the wind is deduced from the tension in the cotton. The effect of the wind on the cotton is neglected, but it appears doubtful if this is justifiable. With cotton 0·2 mm. in diameter, the area exposed to the wind is nearly one-third that of the ball used.

Pilot balloons are usually small balloons 2–3 feet in diameter, which are sent up to determine the wind at different altitudes. Observations are made by theodolites at the end of a base line, or at times by one theodolite, the rate of ascent in that case being calculated from the free lift and diameter of the balloon.

It is assumed that the rate of ascent is given by

$$L = k\rho v^2 r^2 = \mu v^2 r^2,$$

where L is the free lift, r the radius of the balloon, v the upward velocity, ρ the density of the air, and k a constant. The values of μ, calculated from ten sets of observations given in the report, show great irregularity, varying between $5·5 \times 10^{-4}$ and $15·6 \times 10^{-4}$ in C.G.S. units, or between 1/480 and 1/170 in the units used in this part of the report (grains, feet, minutes). Unfortunately, no information is given, and no reasons are put forward, to account for the variations, beyond a vague suggestion of convection currents. It would be interesting to know how much of the variation could be attributed to (1) the deposition of dew on the balloons, (2) the effect of solar radiation on the balloon's temperature, (3) differences in the wind, (4) errors in the observations. As they stand, the results indicate that observations made with one theodolite may give very erroneous values for the wind.

An interesting table gives the values of μ^{-1} obtained by six different methods. From his experiments with a whirling machine, Dines found 240. Observation of a small 3-inch ball, falling through 200 feet, gave 280. Dines's theodolite observations give 290, those of C. H. Ley 330, and twelve ascents of registering balloons 322. Stanton found a still higher value, 354, from laboratory experiments on a $1\frac{1}{2}$-inch ball. It is of interest to note the close approximation to the corresponding value, 380, deduced from the value of k given by Allen's experiments with steel balls in water.

Registering balloons of about 1 metre diameter, having a free lift of 200 to 300 grammes, are used to carry a meteorograph, which weighs, with its case, 60 grammes only (28 grammes without the case). About 60 per cent. of the balloons sent up are recovered, and it seems remarkable that the proportion is higher in winter, the season of high winds, than it is in summer. The explanation given is that when the meteorographs fall in standing crops they frequently come into contact with mowing machines, and as the instrument case resembles an old tin can it is not surprising that Hodge neglects to gather up and return the fragments. The difficulty might be overcome by attaching a partially filled small, cheap balloon, which would act as a signal for some time after the instrument reached the earth. An addition of 5 per cent. to the number recovered would compensate for the extra cost.

The meteorograph is shown in Fig. 2, and diagrammatically in Fig. 3. The aneroid box A expands under decreasing pressure and opens the frame in which it is fixed, so that E, L move across the plate beneath them. If the temperature is constant they make two parallel traces; if the temperature falls, the German silver strip M contracts more than the invar strip HC, and rotates DE about C. Thus, the abscissæ of the trace give the pressures, and the distance between the traces the corresponding temperatures. The instrument furnishes no information as to the rate of ascent.

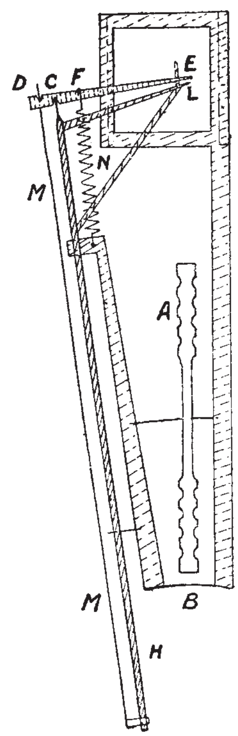


FIG. 3.

It is a great advantage that the calibration of the instrument is made on the actual plate, which is fitted ready for the ascent, and that the pressure and temperature are varied together. It ought, however, to be explained why the instrument is tested down to $-40°$ C. and to 100 mm. only, when it is to be exposed to temperatures of $-60°$ C. and pressures of 50 mm. or less.

The heights have been obtained from the recorded pressures by the use of diagrams, and more recently by means of semi-logarithmic squared paper. The need for great care in dealing with this problem is illustrated by the errors in the table on p. 7. On July 29 the difference of pressure

between 11 and 12 km. is 20 mm. at Manchester and 28 mm. at Pyrton Hill, which has a higher temperature at that height. Similar differences occur between 13 and 14 km., and between 5 and 6 km.

Great difficulty is experienced in reconciling the temperature observations with the observed and expected decrease in wind velocity in the advective region. The obvious errors noted above may be partly responsible for the extraordinary velocity of 150 m.p.s., found from the horizontal gradient of pressure at 16 km. But apart from errors of calculation, an error of only 1° C. in the mean temperature of the air column would produce an error of nearly 3 mm. in the pressure at 16 km. It must also be remembered that where convection is prevented the condition of steady motion may never be reached, and the differences of pressure may be equalised by translation of air across the isobars with moderate velocity.

Dr. Shaw finds that if the lower surface of the advective region is depressed owing to a disturbance in the lower atmosphere, there will be an increase of temperature of 9° C. per km. of depression. Such a depression would presumably be propagated with the same velocity as the disturbance, but the obstacles to convection in the advective region may make the upper portion of the atmosphere act as a damping agent by which the disturbance would be annulled.

The mean, maximum, and minimum values of H_c and T_c, the height and temperature at which the advective region begins, are given in the table:—

	Mean H_c	Mean T_c		H_c	T_c
Manchester	11·6 km.	219° A	Max.	15·2 km.	241° A
Pyrton Hill	12·0 ,,	217° ,,			
Ditcham ...	12·2 ,,	221° ,,	Min.	7·8 ,,	204° ,,
Crinan ...	11·0 ,,	226° ,,			

The values are higher than the mean values found by the present writer and Harwood. The difference probably arises partly through the method of fixing H_c, partly owing to the exclusion of the 1909 results from the present report.

It is a pleasure to note that pressure is expressed in megadynes per cm.², and temperature in degrees C. above the absolute zero. The report is full of interest to all engaged in upper-air research, and will be especially useful to those who are contemplating the establishment of new experimental stations.

E. GOLD.

THE HISPAR GLACIER.[1]

DR. AND MRS. BULLOCK WORKMAN, the well-known explorers of the higher Himalayas, have read before the Royal Geographical Society a most interesting account of the Hispar Glacier. This is one of a group of four of the world's greatest mountain-glaciers, which, together with two others of them—the Biafo and the Chogo Lungma—and some of their tributaries, have been explored from end to end by these indomitable climbers. The Hispar Glacier, one of the many feeders of the Indus, occupies a long and nearly straight valley, running roughly parallel with the crest of the Karakoram—one of the watersheds of Asia. Here that is gashed by rather short and steep transverse valleys, altogether nine in number, and attains an elevation often exceeding 20,000 feet above sea-level. On the southern side is another mountain wall, not quite so lofty, though even its lowest point is quite a thousand feet above the summit of Mont Blanc. From its western part—rather more than fifteen miles in extent—six tributary glaciers—three of them large—descend to the Hispar, but its eastern and upper portion—fully twenty-one miles in length—is practically unbroken. A rather long and flat snow saddle, 17,500 feet above sea-level, parts the Hispar from the Biafo Glacier, which descends towards the south-east, and the total length of the former, from its termination near Hispar village, at a height of about 11,000 feet above sea-level, is, according to Dr. Workman's measurement, a little less than thirty-seven miles, or a mile and a half greater than that assigned to it by Drs. Calciati and Koncza.

The pass over the Hispar and Biafo glaciers, according to Lieut.-Colonel Godwin-Austen, who, about half a century ago, explored these ice-clad fastnesses, was in former times occasionally used by natives, especially marauders, but when Sir Martin Conway traversed it in 1892[1] he found the traditions were very vague. The only serious difficulties are those due to the length of the journey at such a considerable height above sea-level. These, however, did not prevent Dr. and Mrs. Workman from spending several weeks on their way over the pass from Hispar village to Askole, and carefully studying this ice-clad region.

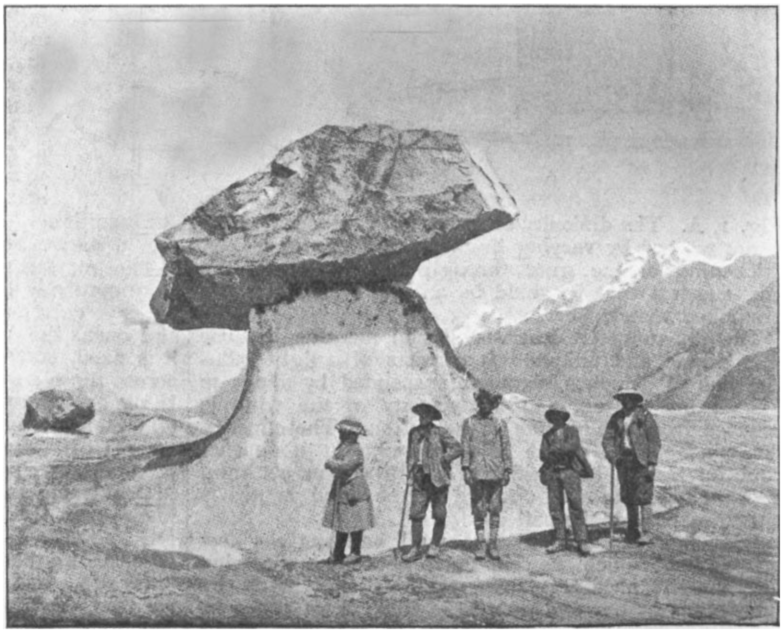


FIG. 1.—A glacier-table of unusual size met with on the lowest third of the Biafo Glacier at an altitude of about 3660 metres (12,000 feet). The rock-boulder was 5 metres (16·4 feet) long, the ice-pedestal 3·8 metres (12·46 feet) high, and the height of the whole 5·5 metres (18 feet). A table with much lower pedestal seen in distance at left. (From the *Geographical Journal*.)

The Hispar Glacier has a low gradient—on the whole about one in thirty—and its average width is a little less than two miles. It receives, as has been said, six large tributaries from the northern side, and three, also large, on the lower part of its southern side. All, and especially the former, are laden with débris to an unusual extent. The effect of this is

[1] The Hispar Glacier. I. Its Tributaries and Mountains. By Fanny Bullock Workman. II. Prominent Features of its Structure. By William Hunter Workman. (*Geographical Journal*, vol. xxxv., pp. 105–31, February, 1910.)

[1] See "Climbing and Exploration in the Karakoram-Himalayas," by W. M. Conway, chapters xvi–xix. (1894.)